A BIOMECHANICAL APPROACH TO COMPARE STEPBACK AND PUNCH THROUGH SINGLE AND DOUBLE LEG TECHNIQUES IN BOXING

SHORT SYNOPSIS

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by

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Certificate

1 hereby declare that the short synopsis **"A biomechanical approach to compare stepback and punch through single and double leg techniques in boxing"** being submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Physical Education under faculty of Lakshmibai National Institute of Physical Education, NERC, Guwahati, Assam during the academic year 2023-24.

It is Bonafide record of original work carried out under the supervision of Dr. Hem Chandra Joshi and has not been submitted in full or part to any other university or institute for a degree or diploma. Further it is certified that the short Synopsis is plagiarism-free and the proof has been submitted.

29/4/2025

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Abstract

The purpose of the study is to investigate about "a biomechanical approach to compare stepback and punch through single leg and double leg technique in boxing" .For the purpose of the study, fifteen (N=15) National level male boxers with the age ranging from 17 to 24 years old. It will also be considered that subjects possess a reasonable level of technique of step-back and punch through single-leg and double-leg technique in boxing. It will also be considered while selecting subjects that the subjects must be free from any orthopaedic and other health related disorders. The subjects will also be selected by using purposive sampling. Participants will arrive at the laboratory. The subjects will assemble and brief about the procedure of the EMG Test. They will also give the consent form and health questionnaire before performing the test. The subject accordingly completing the consent form and health questionnaire. They will be advice to wear appropriate boxing kits before performing the test. After than they will start warm up by doing slow jog and stretching and followed by light shadow boxing so that they get familiarized with the playing environment. Next, Six electrodes will placed at the same time on the skin over the muscles of interest. Surface electromyography (EMG) data will normalize across subjects using EMG results from 5s maximal voluntary contractions (MVC) targeting each muscle. Each skill will be digitally recorded and evaluated. Subjects were asked to avoid doing intensive exercise 24 h before the tests. During the test, they will be told to exert their maximal effort and perform the skill to the best of their abilities. Videography technique will be used to capture the whole motion of the skill and then after the execution of the skill, in biomechanically analysed to identify all selected kinematic variables by using kinovea software.

To obtain reliable measurement, the instruments which will be used for the purpose of the present study, namely, tripod stand; high speed motion analyser camera will be available from the research laboratory of Rajiv Gandhi University and Lakshmibai National Institute of Physical Education. Electromyography with 6 channels will be available from research laboratory of Rajiv Gandhi University and Lakshmibai National Institute of Physical Education and their reliability is ensured by the manufactures. For digitizing the motion into biomechanical variable kinovea software will be used in the study. Data will be collected in the controlled condition so that the research can ensure the reliability of data for his study. All the measurements about the selected variables will be taken by the research scholar under the expert's guidance, so the data collection for the present study will be considered to be reliable.

Keywords : Surface electromyography, Maximal voluntary contractions, Boxing, Electromyography, Biomechanics, Videography

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1 INTRODUCTION

Boxing is a combat sports where two people fighting with their fists, it is the most ancient of all sports. Biomechanics has advanced tremendously during the past 40 years. The biomechanics community has expanded as a result of the emergence of national and international societies devoted to the field as well as the rise in the number of academic journals in the field (D. P. Kumar, 2021). Performance enhancement in exercise or sport is the ultimate goal of sport and exercise biomechanics. Injury prevention and rehabilitation are secondary objectives. The most typical way to increase performance in many sports is for an athlete to work on their technique (McGinnis, 2013) .

A scientific analysis helps to develop new techniques which assist the athletes and coaches in the improvement their performance and the scientific study leads to find out the best n correct techniques for better results. For instance, in case of high jump, there are so many well-known styles to jump higher like straddle, Fosbury's flop, Scissors, back layout (Modified scissors), Western roll, Eastern cut off and so on but researcher has proved that most economic technique is the Fosbury's flop. As in this style the centre of gravity of the athletes do not lift above the bar and remain outside of the body, and passes through or below the bar as the jumper passes over it (Hay, 1985).

In Biomechanical analysis there are various tools and technologies are used to study human movement and its mechanical aspects. Some common equipment used in biomechanical analysis includes: motion capture system, force plates, electromyography (EMG), pressure sensors etc. The event of technology, mechanics ways, and knowledgeable data and therefore the associated article intelligence have enabled a totally new approach of learning the good fortune of athletes supported knowledgeable modelling (Masson, 2010).

The kinesiological diagnostic procedure areas of analysis are often summarized as studies of traditional muscle operate throughout hand-picked movements, studies of muscle activity in complicated sports. A conventional kinesiological approach is surface electromyography (SEMG) for this non-invasive assessment of muscles. One among the parameters to measure the muscular potential activity is the root-mean-square value (RMS). This parameter is commonly wont to characterize myogram amplitude for isometric contractions. The EMG/force relationships in human muscles have long been studied. They suggest a linear and non-linear relationship for isometric contractions and point out that muscle characteristic (i.e.,

fibres type), recordings (i.e., electrode placement, skin impedance),force rate development and subject all influence this relationship. By and by, the sufficiency of the surface EMG dependably increments as a component of time and in this manner as an element of drive yield amid isometric constrictions (S. Bernasconi, 2004).

EMG (electromyography) is often used in sports to study muscle activity and performance. It's valuable for understanding how muscles work during different movements, such as running, jumping, or throwing. For example, in boxing, EMG can be used to analyze muscle activation patterns during punches, assess muscle fatigue levels, and optimize training programs. Researchers and trainers use EMG data to fine-tune technique, prevent injuries, and improve overall athletic performance.

The basic stance

In the basic stance the feet are comfortably apart with the left foot in front of the right and slightly turned in. The distance between your feet should be whatever gives you a solid, balanced feeling; but 12 to 14 inches should be a minimum, so that you cannot be pushed off-balance easily. This position puts you sideways, with the left side of your body in a straight line with your left leg. This offers a smaller target to your opponent (Gary,2012).

The right cross

The left jab and the right cross form the classic one-two, the perfect combination in boxing. The jab opens the offensive and the right cross closes it. Deliver the right cross from the classic stance. Hit right from the shoulder, with all of your weight behind the punch. Raise your elbow so that your arm is almost straight. As your arm crosses over from the right to the left side, your glove should be turned so that the laces are down. Your right leg should move forward as you step in with your left, and your weight should shift directly over to your straight left leg. In this manner, as you turn your hip and shoulder to the left, you will be able to deliver a sharp, stunning blow to your opponent’s head. Maintain the proper balance and hold your left hand close to your body in a guarding position so that you are not left open to a counterpunch by your opponent (Jeffrey,2019).

Step-back and punch

The step-back and punch technique in boxing involves a strategic combination of footwork and striking. When executing a step-back, a boxer moves backward quickly and creates distance from the opponent while maintaining balance and readiness. This move can be defensive, allowing the boxer to evade incoming strikes or create space for a counterattack. The punch technique, on the other hand, focuses on the mechanics of delivering a powerful and accurate blow. Factors such as weight transfer, hip rotation, shoulder alignment, and timing play crucial roles in generating maximum force and precision. Combining the step-back with a well-executed punch enhances the boxer's tactical arsenal, enabling them to control the pace of the fight, set up combinations, and capitalize on openings in their opponent's defence (Thomas,2010). There are two ways to perform this technique i.e. single leg stepback and punch and double leg stepback and punch.

Single leg stepback and punch

The single-leg step-back and punch technique in boxing is a dynamic movement that combines balance, agility, and striking power. In this technique, a boxer shifts their weight onto one leg while simultaneously stepping back with the other leg, creating distance from the opponent. This movement can be used defensively to avoid an incoming attack or to create an angle for a counterpunch. As the boxer steps back, they maintain a strong stance on the supporting leg, engaging core muscles for stability and balance. Once the desired distance is achieved, the boxer swiftly transitions their weight back to the stepping leg and delivers a punch with precision and power.

Double leg stepback and punch

The double-leg step-back and punch technique in boxing also called jumping back and punch and it involves a strategic combination of footwork, balance, and striking prowess. In this technique, the boxer simultaneously steps back with both legs, creating a significant distance from the opponent while maintaining a stable and balanced stance. This movement is often used defensively to evade an opponent's attack or to reset the distance during a bout. As the boxer executes the double-leg step-back, they keep their weight evenly distributed, ensuring optimal balance and readiness to counter or launch an offensive move. Once the desired

distance is achieved, the boxer transitions smoothly into a punch, utilizing proper body mechanics, hip rotation, and timing to generate power and accuracy.

In a nutshell, the single leg and double leg stepback back technique is one of the most important counter attack technique but there is very limited study is conducted in this regard. The researcher have chosen this study to feel the research gap by applying biomechanical approach which involve both kinetic and kinematic variables to properly understand the technique. The outcome of the study may be helpful to identify the pattern of muscles responses while performing stepback and punch executing through single and double leg technique in boxing.

2 LITERATURE REVIEW

Kumar et al. (2022) studied the peak muscle activity (EMG) in youth male national-level boxers during four types of jab techniques. The long-range head jab (LRH) produced the highest EMG for the deltoid and biceps. The medium-range body jab (MRB) generated the highest activity in the other muscles. While there were some differences in muscle activation between the jab types, the most significant difference was seen in the anterior deltoid, with the LRH jab showing the highest activation compared to the others. Overall, the pattern of muscle activation decreased from LRH to LRB, MRH, and MRB.

Eginyan et al. (2021) studied how boxing and battle rope exercises impact seated balance and trunk muscle activity in people with motor-complete spinal cord injury (mcSCI). The study compared 4 individuals with mcSCI to 4 able-bodied controls while recording muscle activity (EMG) and joint angles during these exercises. Results showed that people with mcSCI had higher trunk muscle activation than the controls, but they had reduced trunk rotation and increased trunk curvature.

Lenetsky et al. (2020) analysed the phases of four types of boxing punches (lead punches, rear straight, and hook punches) by studying 10 experienced boxers. They used a mix of ground reaction force measurements, electromyography, high-speed video, and striking data to break down the punch into phases. This research created a structured framework to better understand and describe the mechanics of each punch, offering valuable insights for coaches and sports scientists, and setting the stage for future research on punching techniques.

Shaukat et al. (2020) studied the forces and muscle activity involved in two types of punches—the jab and the cross—performed by 10 healthy males. Using a force plate and

electromyography (EMG), they found that both punches delivered similar average forces. However, the triceps were more active than the biceps in generating the force for both punches.

Omorczyk et al. (2018) compared the stability of gymnasts in standing and handstand positions across different skill levels. They found that senior athletes had significantly better stability than juniors, with lower values in measures like sway area, COP displacement, and statokinesiogram path length. In contrast, juniors showed no correlation between their stability in standing and handstand positions. The study concluded that a gymnast's level of advancement plays a key role in their ability to control balance in both positions, and standing stability measures aren't useful for predicting handstand balance in junior athletes.

Iwamoto et al. (2014) studied how beginners and experienced boxers differ in executing a right straight punch. The research involved 10 male participants—5 experienced boxers and 5 beginners—and measured punch speed, balance, and muscle activity using EMG. While the duration of each phase of the punch (Preparation, Acceleration, Deceleration, and Restoration) was similar for both groups, significant differences were found in muscle activation timing and intensity. The findings highlighted key areas where beginners could focus their training to improve punch execution.

Pauk et al. discussed the challenges of interpreting electromyography (EMG) signals and the need for advanced techniques to analyze them. The paper reviews methods like filtering, wavelet transforms, and modelling, comparing their effectiveness for EMG signal analysis. It provides valuable insights for researchers, helping them better understand and process EMG signals to improve biomedical applications.

Dyson et al. (2007) studied muscle activity during punching in six competitive male boxers. They found that the best muscle recruitment pattern for delivering maximum force, especially when punching the body, involved muscles like the rectus femoris, gastrocnemius, and biceps femoris. Punches aimed at maximum force were 38% stronger than those aimed at speed, with increased activation in the rectus femoris, which helps extend the rear leg during the punch..

Reaz et al. (2006) explored how electromyography (EMG) signals are used in various fields like clinical research, prosthetics, and human-computer interaction. The study highlights the complexity of EMG signals and stresses the need for advanced methods to detect, process, and classify them. It reviews different analysis techniques and hardware applications, such as

prosthetic hand control and grip recognition, offering valuable insights for creating more effective EMG-based technologies.

Lockwood and Tant (1997) studied the body mechanics and muscle activity involved in throwing a maximum force jab in professional and amateur boxers. They found that professionals generated more punch force, wrist speed, and elbow speed than amateurs. While both groups had similar muscle activation patterns, professionals showed better timing and muscle engagement. The study suggested that resistance training focusing on leg extension, core strength, and shoulder flexion could help improve punch force, with traditional boxing exercises like jump rope, sit-ups, and push-ups already supporting speed and power development.

3 DESCRIPTION OF BROAD AREA

Biomechanics

"Biomechanics is the science concerned with the internal and external forces acting on a human body and effect produced by these forces**"**(Hay, 1993).

Quantitative analysis

Quantitative approach is a method which is more better than qualitative approach because in qualitative approach we rely on data which is in numerical form but in qualitative approach there is an absence of numerical data, because of this reason quantitative approach is more scientific (T. Boone, 2012).

Kinetics

"Kinetics is the branch of biomechanics that deals with what cause a body to move in a way it does" (A. K. Uppal, 2012).

Electromyography

"Electromyography is the recording of the electrical activity of the muscles, and therefore constitutes an extension of the physical exploration and testing of the integrity of the motor system" (Masson, 2010).

Kinematics

Kinematic is a branch of mechanics which deals with the motion of the bodies without considering the force involves in it (Danica, 2018).

Centre of the Gravity

The **centre of gravity** is the point in the body where its weight is evenly balanced in all directions. You can think of it as the spot where your body's mass feels most concentrated. It's the point that helps you stay balanced and stable, no matter how you move or position yourself (Hall, 1991).

Single leg stepback and punch

In this technique the boxer from his stance position pulls back his\her right leg backward and then executing the right straight punch with right leg coming back to its original stance position.

Double leg stepback and punch

In this technique the boxer from his stance position jumps backward with both leg and then executing the right straight punch with both legs coming back to its original stance position.

4 OBJECTIVES OF THE STUDY

PROBLEM STATEMENT

Boxing as a sport has dynamism as a characteristic which involves the participation of both lower and upper body muscular system and its coordination with other systems so this poses an opportunity to enlighten the relationship between lower body muscles and types of punching techniques in boxing. This motivated the researcher to investigate about "a biomechanical approach to compare stepback and punch through single leg and double leg technique in boxing"

RESEARCH OBJECTIVES

1. To find out the muscle activation pattern during step back and punch through single leg and double leg in boxing
2. To find out the differences between step back and punch through single leg and double leg in boxing
3. To find out the major muscle responsible for the execution of step back and punch through single leg and double leg in boxing
4. Kinematically analysis of step back and punch through single leg and double leg in boxing
5. To find out the difference in selected kinematic variables in step back and punch through single leg and double leg in boxing

Delimitation

Since, the study will be conceptualized with a very specific purpose for selected subjects. The following delimitation are given below:

1) The study will be confined to 15(N=15) National Level male boxers of Arunachal Pradesh only.
2) The study will be further confined to obtaining data from right side only (unilateral measurement).
3) The study will focus exclusively on orthodox stance boxers aged between 19 and 25 years.
4) The sample will be further limited to lightweight boxers (weighing over 46 kg and up to 60 kg).
5) The study will be further delimited to the Biomechanical analysis of the contact phase of step back and punch through single leg and double leg in boxing
6) The study will be restricted to the analysis of the following biomechanical variables:

i. Kinetic Variables:

The average rectified EMG score and the muscle part will be recorded of the following muscles:

a) Rectus Abdominis
b) Gastrocnemius
c) Bicep femories
d) Semitendinosus
e) Rectus femories
f) Vastus laterals

ii. Kinematic Variables:

a) Height of centre of gravity at moment of contact phase while executing step back and punch through single leg and double leg in boxing
b) Velocity of the punch while executing step back and punch through single leg and double leg in boxing.
c) Temporal Variable (Total time taken to complete the action of executing step back and punch through single leg and double leg in boxing).

Hypotheses

On the basis of research cited, books depiction, scientific facts available and research scholar own understandings of this research study following hypotheses were formulated:
It will be hypothesized that-

1. There will be a significant differ between muscle activation in single leg stepback and punch and double leg step back and punch.
2. There will be a significant variation in contribution of selected muscles while executing step back and punch through single leg and double leg in boxing.
3. There will be significant difference in selected Kinematic variables during step back and punch through single leg and double leg in boxing.

5 RESEARCH METHODOLOGY

Selection of subjects

For this study, fifteen (N = 15) national-level male boxers between the ages of 17 and 24 will be selected. All participants will be required to demonstrate a good understanding and skill level in executing the step-back and punch technique using both single-leg and double-leg variations. Care will be taken to ensure that all selected boxers are in good health and free from any orthopaedic or other medical conditions that could affect their performance.

Based on the researcher's understanding of the topic, insights from expert consultations, and a review of existing literature, the following variables have been selected to compare muscle activation and electromyographic (EMG) patterns during the single-leg and double-leg step-back and punch techniques.

A. The study will be confined to the activity in the following selected muscles:

i. Rectus Abdominis
ii. Gastrocnemius
iii. Bicep femories
iv. Semitendinosus
v. Rectus femories
vi. Vastus laterals

B. Kinematic Variables:

i. Height of COG at moment of contact phase while executing step back and punch through single leg and double leg in boxing

ii. Velocity of the punch while executing step back and punch through single leg and double leg in boxing.

iii. Temporal Variable (Total time taken to complete the action of executing step back and punch through single leg and double leg in boxing).

C. Electromyographical parameters:

i. Average Rectified EMG Value (ARV): Average muscle activity for each condition.

ii. **Muscle's part:** It represents the contribution of each muscle in the total muscle activity (SUM) for each condition and was expressed in percentage. The muscles' part was determined by using formula $\frac{\text{ARV}}{\text{SUM}} \text{x } 100$; where ARV is the average ractified emg score which represent the avarage muscle activity of each muscle in each selected condition and the SUM is the estimate of total muscle activity in each condition which was determined after summing of ARV of all muscles studied for each subject in each condition. As the summation of all muscle parts for each condition is equal (100%), a different muscle part for one muscle between all three selected conditions represents a different contribution of this muscle in the total muscle activity (SUM).

Criterion measure

The following criterion measure will be used for conducting the research:

Variable	Criterion Measure	Instrument Used	Unit
Rectified EMG score	**Micro-volt**	**EMG device**	**µV**
Muscle Part	**Percentage**	**EMG device**	**%**
Height of centre of Gravity	**Centi-meter**	**Kinovea**	**cm**
Temporal Variable	**Seconds**	**Kinovea**	**S**
Velocity of action	**Kilo-meter per hour**		**Km/hr**

Procedure for administration of test

Participants will report to the laboratory, where they will first be gathered and briefed on the procedure for the EMG test. Before beginning, each participant will complete a consent form and a health questionnaire to ensure they are fit for the study. They will also be advised to wear appropriate boxing attire for the session. To prepare for the test, participants will warm up with a light jog, stretching, and some shadow boxing to help them get comfortable in the testing environment. Once warmed up, six surface EMG electrodes will be placed on specific muscles of interest on the body. To ensure consistent results across all participants, EMG data will be normalized using a 5-second maximal voluntary contraction (MVC) for each targeted muscle.

Each boxing skill performed will be recorded digitally. Participants will be instructed to give their best effort and perform the movements with maximum intensity. To capture the full motion of each technique, videography will be used throughout the session. After the skills are performed, the recorded footage will be analysed using Kinovea software to assess the selected kinematic variables in detail.

Reliability of data

To ensure reliable measurements, the necessary instruments for this study, including a tripod stand and a high-speed motion analysis camera, will be provided by the research laboratories at Rajiv Gandhi University and Lakshmibai National Institute of Physical Education. Additionally, a six-channel electromyography (EMG) system will be available from these same laboratories, and its reliability is guaranteed by the manufacturer. To analyze the motion and convert it into biomechanical variables, Kinovea software will be used. Data will be collected under carefully controlled conditions to maintain consistency and accuracy throughout the study. All measurements of the selected variables will be taken by the research scholar, with guidance from experts in the field. This process will ensure that the data collection is both accurate and reliable for the purposes of the study.

Instrumentations

Two major instruments will be used for collecting the data of required movement. The biomechanical variables will be determined by using videography technique and Electromyographical variables will be determined by using surface EMG (S-EMG). To record the muscles activities during the skill on all selected apparatuses cordless Electromyography will be used so that the Boxers can perform the skill without any cord interruption. When administering the EMG, the researcher will make sure of the following:

1. All electrodes will be carefully placed on the six target muscles, following their correct anatomical reference points.
2. The electrodes will be placed on the right side (unilateral) of the body, ensuring consistency and accuracy in the measurements.

To conduct statistical analysis, we will going to use SPSS (Statistical Package for the Social Sciences, version 20.0).

For statistical analysis

To conduct statistical analysis, we will going to use SPSS (Statistical Package for the Social Sciences, version 20.0).Descriptive statistics, including mean and standard deviation, will be calculated to examine the differences in the selected biomechanical variables (both kinetic and kinematic). A two-sample t-test will be performed at a 0.05 level of significance to assess these differences. Additionally, a pie chart will be used to visually analyze the EMG activation patterns (muscle contribution) during the step-back and punch, comparing the single-leg and double-leg techniques in boxing.

6 EXPECTED OUTCOMES OF THE RESEARCH

1. The study may educate the coaches regarding the role played by different biomechanical variables in achieving the economic technique of stepback and punch executing in boxing.
2. The findings of the study may also help coaches to work on the particular group of muscles that will help in single and double leg stepback and punch technique in boxing.
3. The results of the study may help the boxing players and coaches in a general understanding of the major muscle group which affects the single and double leg stepback and punch technique in boxing.

4. The study may help to identify the contribution of selected muscles while executing the stepback and punch executing in boxing.
5. The study may be helpful to identify the pattern of muscles responses while performing stepback and punch executing through single and double leg technique in boxing.
6. Similar kind of study may be undertaken in other kind of sports to understand the scientific principles involved in it.

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